BULL MOOSE BEHAVIOR AND MOVEMENTS IN RELATION TO HARVEST ON THE KENAI NATIONAL WILDLIFE REFUGE

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Abstract - The movements, behavior, and mortality patterns of bull moose (Alces alces) were examined to evaluate moose harvest strategies on the Kenai National Wildlife Refuge, Alaska. Seven radiocollared adult bull moose were aerially located 242 times from November 1980, to September 1983. Four migratory bulls had larger home ranges (165 km^2) and different movement patterns than three bulls that were residents (59 km^2) in early successional stage forest. All were legally harvested by hunters in early succession stage forest where they had been tagged within three years. Migratory bulls that traveled into early successional stage forest to breed lived longer (x=6.5 years) than resident bulls (x=4 years) because they were generally in remote locations and thicker cover during the September 1-20 bull-only hunting season. Bull moose behavior and movement patterns changed with the onset of the rut in mid-September. This made them particularly susceptible to harvest because moose moved into open areas and formed larger groups. High hunter accessibility and hunting pressure in early succession stage forest lowered the average age of bulls and modified the moose population composition to below 20 bulls/100 cows despite an expanding moose population. Hunting seasons in early September concentrated harvest on resident moose near roads, while hunting after September 15 harvested both resident and migratory moose and impacted moose over a much larger area.

Alces

The Kenai Peninsula was a famous trophy moose hunting area in the 1910's (Whitney 1916). Sportsman concern for the declining moose population was the primary reason the Kenai National Moose Range was established in 1941 (Spencer and Hakala 1964). The major purpose of the Moose Range was "to provide for the natural feeding and breeding grounds and practical management of the giant Kenai moose." While the major purposes and name of the refuge were changed to emphasize natural diversity and multispecies wildlife management direction with passage of the Alaska National Interest Lands Conservation Act (ANILCA) in 1980, moose continued to be an important species due to high public interest and their important role in the lowland boreal forest ecosystem. The Kenai National Wildlife Refuge's primary purpose of conserving fish and wildlife populations and their habitats in their natural diversity required an expansion of knowledge regarding the refuge's free roaming moose population.

As part of an investigation of the impact of winter oil exploration activities on moose, seven bull and 51 cow moose were radiocollared and monitored by aerial tracking from November 1980 through September 1983 (Bangs and Bailey 1982). Moose management has become more complex on the refuge due to a rapidly increasing human population, increasing hunter pressure, changes in the major purposes for which the refuge will be managed, and an increasingly diverse number of user groups. Moose hunting by regulation is primarily for bulls on the Kenai Peninsula. Approximately half of the harvest, approximately 6-700 annually, occurs on the refuge lowlands. Data gathered on radiocollared bull moose from the western lowlands were examined to evaluate moose hunting programs on the roaded accessible portions of the refuge where both moose densities and hunter effort are high. This information may not apply to different areas where there is less access, different terrain, or poorer quality moose habitat.

STUDY SITES

The Kenai National Wildlife Refuge is located on the western half of the Kenai Peninsula 12 km due south of Anchorage, Alaska. The refuge has the highest public use and is the most easily accessible of any Alaskan refuge. Development is rapidly increasing along its western boundary. The refuge's location, history, habitats, and moose population history have been previously described (Spencer and Hakala 1964, Oldemeyer et al 1977, Bangs et al. 1982).

Moose were radiocollared in two important wintering areas in 1980 (Fig. 1). The Slikok Lake study area was burned in 1926 and 1,170 ha were mechanically rehabilitated in the mid-1960's. The Finger Lakes study area was burned by a 34,000 ha wildfire in 1969. Both the Finger Lakes and Slikok Lake areas are road and trail accessible and encompass 15-20-year-old early successional stage forest, regrowth forest burned in 1947, mature forest, and various wetland habitats although the proportion of each varied greatly (Bangs and Bailey 1982). Bull moose in both these areas are intensively harvested during a September 1-20 bull-only hunting season. Wintering moose densities in both study areas are about four moose/km^2 and calf production and recruitment is high, with over 50% of the annual moose harvest comprized of yearling bulls. Aircraft are prohibited from September 1-10, in the northern portion of the refuge which includes the Finger Lakes study area, but not the Slikok Lake study area.

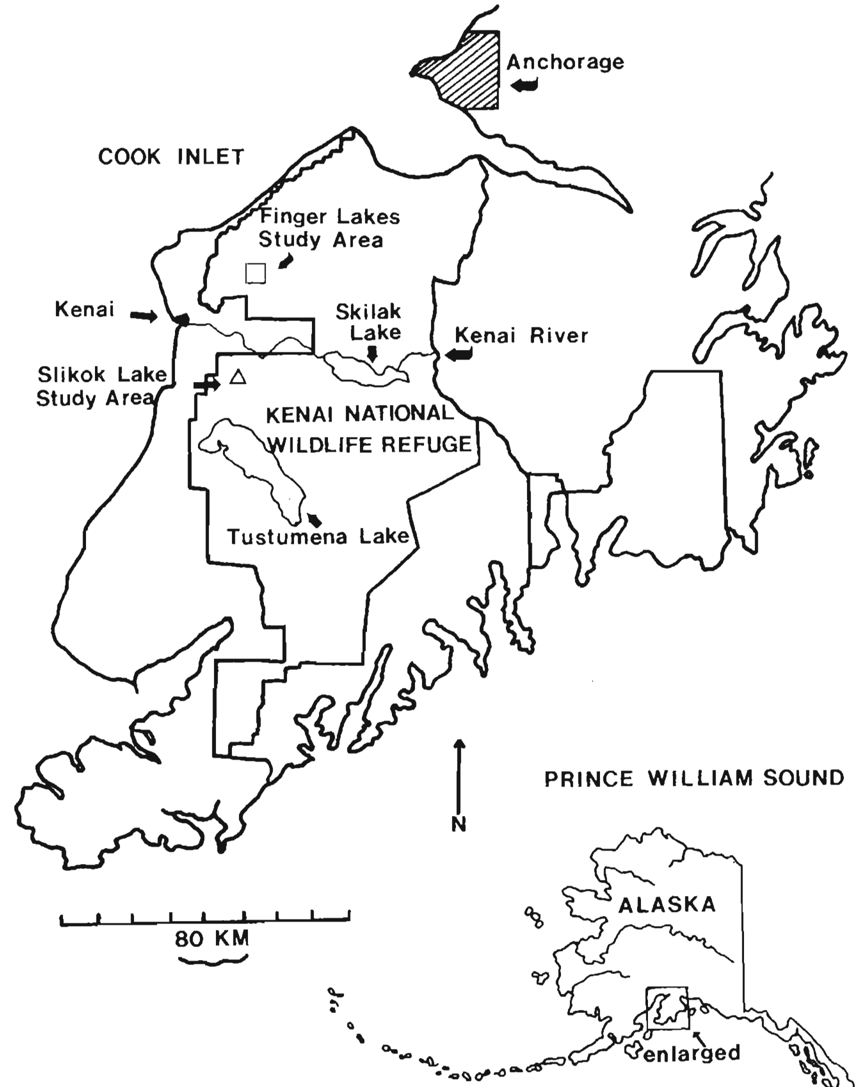

Figure 1. Location of Slikok Lake and Finger Lakes moose study areas on the Kenai National Wildlife Refuge, Alaska.

METHODS

Moose were radiocollared and ear tagged in 1980, utilizing helicopter capture procedures (Hauge and Keith 1981). Twenty-eight moose, two bulls and 26 cows, were tagged near Slikok Lake in late November and 30 moose, five bulls and 25 cows, were tagged in the Finger Lakes area in early December. Calves and yearling moose were avoided during the capture operation. Moose were aged from tooth sectioning (Sergeant and Pimlott 1959) and standard measurements were taken. The 58 tagged moose were located by aerial tracking over 2,200 times since November 1980. The seven bull moose were aerially located 242 times and were seen on 173 of those observations. Seven observations of tagged bulls were reported by the public, six were hunter kills.

The location, activity, behavior, general and specific habitat type, social interactions, and antler development of bulls were recorded for each observation. A moose, with distinct and separate patterns of summer (April-September) and winter (October-March) range use, was described as having a migratory movement pattern. Other moose were described as residents. Home range size was determined by the minimum perimeter polygon method (Mohr 1947). The movement and home range use of radio collared female moose was similar to that observed for marked bulls and was used to support the conclusions reached from the small sample size obtained from bulls (Bangs and Bailey 1982). Data were compared by two tailed t-tests and chi square analysis and were considered statistically different at the 0.10 level.

Post hunting moose population composition and density on the refuge have been monitored by fall and winter aerial surveys since the 1960's (Bailey 1978).

RESULTS AND DISCUSSION

Moose Density and Composition

Moose density on the refuge has varied with the severity of weather and the occurrence of wildfire (Bangs and Bailey 1980). Winter moose density surveys on the refuge indicated approximately 3,500 moose in 1979 increasing to 4,900 moose by 1982. The increase in moose numbers throughout the refuge is attributable to relatively mild winter weather since 1979 and excellent moose habitat created by a wildfire in 1969.

Moose densities on the western lowlands, particularly in the study areas, are at higher levels, about two to four moose/km^2, than the remainder of the Kenai Peninsula, below two moose/km^2, primarily due to the early successional stage forest habitat created by large wildfires in 1969 and 1947 (125,000 ha).

The post hunting fall composition of moose on the lowlands varies greatly with the level of road access, but averages about five or more adult cows per bull (Bailey 1978). The proportion of bulls in the Finger Lakes study area has decreased from 26-51 bulls/100 cows in 1978-79, to 16-14 bulls/100 cows in 1982-83, respectively. The Slikok Lake study area had 14 bulls/100 cows in 1981. The low number of bulls in the lowlands including the study areas contrasts with a permit trophy moose hunting area, 9 km east of the Slikok Lake study area. Access into the trophy area, located between Skilak and Tustumena Lakes, is difficult and harvest is restricted by a permit system in which 100 permits are issued to harvest bulls with antlers wider than 127 cm. Approximately 30 bulls are harvested annually. Moose densities are lower than one moose/km^2. In this area in 1980, there were 48-65 bulls/100 cows with many of the bulls having antlers over 127 cm in width (Spraker 1980).

On the western lowlands, older, large antlered bulls are relatively rare. The average age of captured bulls (3.1 years, range 2-6) (Table 1) was significantly younger than the average age of cows (6.5 years, N=51, range 1-18) ($t=35.2$, 56 df, $P < 0.01$). The highly skewed moose sex ratio and scarcity of older bull moose in the lowland areas was primarily due to a bull only hunting program that has been ongoing since the early 1970's (Peterson et al. 1984).

Table 1. Data on radiocollared bull moose captured on the Kenai National Wildlife Refuge in November-December 1980. Y moose were captured at Finger Lakes, B moose at Slikok Lake.

Bull #	Age at Capture	Antler Spread	Migratory	Home Range Size	Distance Between Capture & Harvest Locations	Date Harvested	Antler Spread When Harvested
Y45	6	127 cm	Yes	56 km^{2a}	1.6 km	09/18/83	127 cm
Y66	3	114 cm	No	54 km^2	11.2 km	09/00/81	Unknown
Y81	3	99 cm	No	37 km^{2a}	9.6 km	09/12/81	Approx 119 cm
Y83	2	93 cm	Yes	147 km^2	3.2 km	09/19/83	122 cm
Y84	2	77 cm	No	64 km^2	3.2 km	09/01/82	113 cm
B39	3	117 cm	Yes	185 km^2	3.2 km	09/18/83	Unknown
B60	3	107 cm	Yes	162 km^2	4.0 km	09/01/83	126 cm

[a]Incomplete home range size due to shed collar.

Distribution and Movements

The home range of bulls varied from 54 km^2 to 185 km^2 and averaged 122 km^2. Although sample size was small, migratory bulls had significantly larger home ranges than resident bulls ($t= 7.2$, 2 df, $P < .01$). Cows had home ranges that averaged 110 km^2 and varied from 25 km^2 to 440 km^2 (Bangs and Bailey 1980). Approximately 43% of both bulls and cows had distinct winter and summer ranges and were classified as migratory which is similar to the 40% migratory moose figure previously estimated for Kenai moose (LeResche 1974). Migratory bulls moved from summer ranges as far away as 22.5 km and cows moved 43 km to use the Finger Lakes wintering area. Migratory moose of both sexes traveled up to 17 km to utilize the Slikok Lake wintering area. Migratory bulls and cows generally moved into the Slikok and Finger Lakes areas in late September and early October. These movements into the early successional forest were abrupt and appeared to begin with the onset of the rut shortly after September 15. These movements increased the susceptibility of moose from as far away as 43 km to harvest or other potential impacts occurring in early successional stage forest. Migratory bulls in both areas moved out of the early successional stage forest into different habitat types in early January as did many cows. Other migratory cows did not show movements to summer ranges until March (Bangs and Bailey 1980).

Behavior

The diurnal activities of radiocollared bulls were different in the winter compared to the summer (x^2=8.9, 4 df, P < 0.10). Bulls were more likely to be feeding and less likely to be lying down when observed in the summer than winter (Table 2). They also appeared to travel more in the summer. The differences in activity patterns between winter and summer are those expected with energy budgeting. When food supplies are limited either by quality or quantity, moose apparently conserve energy by lying and when food supplies are abundant, spend longer amounts of time feeding or searching for food. A similar pattern has been reported for moose by Best et al. (1978). The few courtship and aggressive behavior were observed during the winter, from October-March. Bull moose were usually alone in the summer, but were generally within 100 m of other moose during the winter (x^2=11.7, 1 df, P < 0.01) (Table 3). Bulls associated with significantly higher numbers of moose during the winter particularly from October through December. (t=371.0, 118 df, P < 0.01)

Table 2. The percentage of observed activity of marked bull moose classified by quarters of the year from 1980-1983. (N=No. of observations)

Activity	Jan-Mar N=68	Apr-Jun N=21	Jul-Sep N=22	Oct-Dec N=62
Standing	25	19	23	21
Feeding	13	29	32	18
Lying	53	38	32	51
Traveling	6	14	14	7
Courtship/Display	1	0	0	2

Table 3. The percentage of observations that radiocollared bull moose were with other moose and the average size of groups by quarter of the year for 1980-1983.

	Jan-Mar N=74	Apr-Jun N=23	Jul-Set N=25	Oct-Dec N=65
Alone	35.6	61.0	52.0	21.5
Groups	64.4	39.0	48.0	78.5
Avg Size of Groups	3.5	2.2	3.1	4.2

The composition of moose groups associated with tagged bulls indicated that they were rarely within 100 m of calf moose, and were most commonly associated with other bulls or unidentified adult moose during the October-December breeding period (Table 4). This information on group affiliation and composition was similar to the general patterns that were reported for bulls by Hauge and Keith (1981) in Alberta.

Table 4. The average number of moose in groups that radiocollared bulls were located with, excluding the tagged bull, by quarter of the year for 1980-1983.

	Jan-Mar N=48	Apr-Jun N= 9	Jul-Sep N=12	Oct-Dec N=51
Bull	0.21	0.22	0.17	0.72
Cow	0.46	0.11	1.83	2.23
Calf	0.19	0.00	0.08	0.25
Unid. Adult	1.6	0.89	0.00	0.02

Habitat Selection

During each location, the dominant habitat type within 1 km^2, the specific habitat type the bull was physically in, and the dominant character of the specific habitat were recorded. An example, would be a bull in early successional stage forest (dominant habitat) lying in a remnant mature stand (specific habitat) that was primarily composed of spruce (dominant character). Data on habitat use may be biased since resident moose using early succession stage forest did not survive as long as migratory moose because of hunting and contributed fewer observations. Nevertheless, dominant habitat selection data reflect the strong seasonal shift of migratory bulls into early successional stage forest (x^2=12.8, 3 df, $P < 0.01$) in the winter, particularly during October-December breeding period (Table 5). The pattern of movement into areas with abundant food had been reported previously (Gasaway et al. 1978). The specific habitat data (Table 6) also indicated bulls were extensively utilizing early successional stage forest in the winter, peaking from October through December, compared to summer habitat use (x^2=11.79, 3 df, $P < 0.01$). A comparison of dominant versus specific habitat use suggested bulls that were generally in relatively open early successional stage forest were often physically located in remnant stands of mature timber, frequently spruce. The use of conifer cover has been suggested for both predator avoidance (Stephens and Peterson 1984) and thermal protection (VanBallenberghe and Peek 1971). However, the dominant character of specific habitat types indicated that bull moose were twice as likely (x^2=15.5, 5 df, $P < 0.01$) to be in the open during the winter, particularly the October-December period than the summer months (Table 7). The use of spruce dominated habitats was extremely high during the April-June period (x^2=72.4, 3 df, $P < 0.01$), compared to the rest of the year, as also reported for moose in Alberta (Hauge and Keith 1981). These spruce stands were typically black spruce near lakes or

Table 5. The percentage of locations of radiocollared moose in various dominate habitat types classified by quarter of the year from 1980-1983.

Dominant Habitat Type	Jan-Mar N=92	Apr-Jun N=43	Jul-Sep N=40	Oct-Dec N=73
1947 Burn	13	7	10	4
Early Stage Forest	48	39	39	79
Mature Forest	23	32	39	15
Bog	16	21	10	1

Table 6. The percentage of locations of radiocollared bull moose in specific habitat types classified by quarter of the year from 1980-1983.

Specific Habitat Type	Jan-Mar N=92	Apr-Jun N=43	Jul-Sep N=40	Oct-Dec N=73
1947 Burn	6	10	7	1
Early Stage Forest	37	30	26	58
Mature Forest	37	32	43	35
Bog	20	27	24	5

wetlands that escaped fire and often provided the only cover in large burns. Wetlands appear to be important feeding areas for moose in the spring (Hauge and Keith 1981) and remnant spruce stands may simply be the nearest available cover. Moose could also use thick black spruce to escape the spring sun before losing their thick winter coat.

VanBallenberghe and Peek (1971), working in Minnesota, also commented on the use of black spruce swamp areas by moose during the summer.

Table 7. The percentage of radiocollared bull moose relocations by dominant character of the specific habitat classified by quarter of the year from 1980-1983.

Dominate Character	Jan-Mar N=92	Apr-Jun N=43	Jul-Sep N=40	Oct-Dec N=73
Hardwood	3	0	2	3
Spruce	34	57	36	26
Mix Hardwood/ Spruce	20	14	31	11
Open[a]	40	24	23	50
Water	0	2	0	0
Alder/Shrub	2	2	8	6

[a]Vegetation height below 2.0 m

Mortality

All seven tagged bull moose were eventually harvested by hunters in early succession stage forest during the 20-day moose season. The average distance between capture and harvest locations for migratory bulls was 3 km which was less ($t= 2.35$, 5 df, $P < 0.10$) than 8 km for resident bulls. This indicated that migratory bulls were more likely to be harvested in a specific portion of their home range associated with winter feeding and breeding activities. The pattern in which bulls were harvested was informative. Two resident bulls were killed in 1981, the first hunting season after tagging. Since one bull was killed and the collar shot and left in the woods by an unknown hunter, no information was obtained. The other bull, harvested in 1981, was taken by an aircraft assisted hunter 10 km from the nearest road the day after airplane access opened. Moose hunters are not permitted to hunt the same day that they are airborne. The remaining resident bull was killed the first day of moose season in 1982. All four migratory bulls were harvested in the 1983 season. One bull was taken the first

day of season, September 1, after an unusual movement, 8 km from his usual summer range and location on August 25, into the Slikok Lake rehabilitated area. The remaining three migratory moose were killed during the last three days of the 1983 season. All three apparently moved into early successional stage forest earlier than in previous years, probably for breeding activities, which resulted in their harvest. Resident bulls were taken as 4-year-olds while migratory bulls were older, from five to nine years of age, when harvested ($t=2.44$, 5 df, $P < 0.10$). Migratory moose spent most of the September 1-20 hunting season in areas of thick cover, at least 3.2 km from the nearest road, where they were less susceptible to harvest. Resident bulls were more vulnerable during the hunting season because they were often within 3.2 km of roads and frequented relatively open areas of early successional stage forest. The high vulnerability of moose near roads and population centers has been documented in Canada (Crete et al. 1981, Bider and Pimlott 1973) as has differential vulnerability to hunting (Goddard 1970).

Antler Development

The timing of antler casting was recorded for all tagged bull moose and other observed bulls and was slightly later than that reported by VanBallenberghe (1982) for other Alaskan moose. No radiocollared bull cast antlers prior to December 15, and only one non-radiocollared bull on the lowlands, on November 5, was observed with one antler prior to December 15. Since the vast majority of non-radiocollared bulls retained antlers through mid-December, it appeared that most adult bulls on the lowlands cast their antlers in late December or early January. This was probably an indication of the young average age of lowland bulls since older bulls drop antlers earlier than young bulls (VanBallenberghe 1982).

One 3-year-old collared bull (114 cm spread) cast both antlers between March 22-25, the same winter it was captured. It had normal antler development the following summer with antlers 20 cm long on May 6; by June 5, the antlers were 102 cm wide and palmated. It is possible that this apparently abnormal antler retention was due to capture and drug (M-99) induced stress, since no adult bull on the Kenai has been reported to retain antlers that length of time. Stress has resulted in abnormal antler retention among deer (Topinski 1975). The timing of antler-casting per individual is relatively short but does extend over several days. One five-year old bull cast one antler between December 21-29, and its other antler between January 3 and 25.

CONCLUSIONS

Conclusions from this study of radiocollared bull moose on the western refuge lowlands have implications for refuge management purposes.

Harvest on the Kenai NWR lowlands during the September 1-20 moose season is concentrated on resident bulls near roaded areas particularly in early successional stage forest types, where visibility, moose density, and hunter effort are high.

Moose exhibited different distribution, behavior, and habitat use patterns in the winter compared to the summer. The rut, which begins shortly after September 15, but during the September 1-20 hunting season, starts the transition from summer to winter behavior and range use. This results in increased vulnerability of moose, particularly migrating moose, to hunting, because they moved from remote areas with thick cover into open areas that happened to be near roads. Bulls also were more likely to be with other moose and in larger groups during the rut, which also increased their visibility and vulnerability to hunting. Harvest has greatly lowered the number and age of bulls over a majority of the refuge's lowland moose habitat, particularly near roaded areas.

As a result of the current bull only harvest strategy, hunters have a low probability of harvesting a large antlered bull on the Kenai lowlands. Roadside wildlife viewing opportunities are also effected since viewers and photographers, who generally visit the refuge during the summer, have little opportunity to see large antlered resident bull moose near roaded areas. Since there are few mature bulls available to the majority of refuge visitors, who primarily use the road system, conflicts between user groups has the potential to intensify. Future refuge moose hunting programs should attempt to harvest from a broader spectrum of the moose population to provide for greater diversity of moose sex and age classes.

The impacts of harvest on moose population composition or numbers are increased by hunting seasons occurring after September 15, by building roads or trails in early successional or open forest habitats, and by creating early successional stage forest near roads. The impact of moose hunting will occur over a much larger area if hunting in open habitats with abundant food occurs after September 15, since moose migrate from long distances to utilize these areas. This information is particularly applicable to areas with intensive timber harvest, since access, moose browse, and open habitats are usually created.

Data on the movements of radiocollared bull moose suggest that fall composition surveys are conducted when moose are using discrete traditional breeding and winter feeding areas. Since the mixing of resident and migratory moose on the Kenai occurred by early October, data obtained from fall surveys are biased if composition count data are interpreted as representing discrete summer sub-populations. Composition counts can be conducted into mid-December because few bulls will have shed their antlers prior to December 15. Since breeding groups of moose were often in open habitats and rarely contained calves, an underestimation of calf production may occur from fall counts.

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